

SECTION 02860

JACKING AND BORING

1.0 GENERAL

1.1 WORK INCLUDED

- A. The work under this section includes furnishing all labor, materials, equipment and services required for the installation of approximately 435 feet of a 36-inch minimum outside diameter steel casing approximately 240 feet of which shall be installed by horizontal jack-and-bore method, and approximately 195 feet of which shall be installed by the cut and cover method, as shown on the contract Documents and as specified herein.
- B. The work also includes the installation of approximately 435 feet of a 20-inch inside diameter ductile iron pipe (DIP) within the steel casing, and grouting of the annular spaces around the pipe with cement grout or low density cellular concrete, as shown on the Contract Documents and as specified herein.
- C. The Contractor shall install the ductile iron pipe as shown on the Contract Documents, shall dispose of all excess excavated materials, and shall restore the work sites to the original conditions.

1.2 RELATED SECTIONS

- A. Section 01340 Shop Drawings Project DATA and Samples
- B. Section 02222 Excavating, Backfilling, and Compacting for Utilities
- C. Section 02575 Pavement Repair and Resurfacing
- D. Section 02140 Dewatering
- E. Section 02610 Pipe and Fittings

1.3 DEFINITIONS

- A. Surface Settlement Points: Permanent survey control points established at the ground surface along the pipe alignment or about surface structures and facilities for monitoring surface settlement due to subsurface excavation.
- B. Carrier Pipe: Permanent pipe for operational use that is used to convey water.
- C. Casing Pipe: A pipe installed by Pipe Jacking that supports the ground and provides a stable underground excavation for installation of the product pipe.

D. Jacking Pipe: Pipe or casing specially designed to be installed using pipe jacking techniques.

1.4 QUALITY ASSURANCE

A. Codes and Standards

1. ASTM A283 Specifications for low and intermediate Tensile Strength Carbon Steel Plates, Shapes, and Bars.
2. ANSI/AWS D1.1 Structural Welding Code

B. Tolerances

1. Line and Grade Tolerances: The Contractor shall install the ductile iron pipe to the lines and grades shown on the Contract Documents. The following tolerances apply to the installation of the ductile iron pipe carrier pipe:
 - a. Deviation from proposed horizontal alignment: 12 inches maximum.
 - b. Deviation from proposed grade: 6 inches maximum.
2. Ground Settlement Tolerances
 - a. Highway (I-215) pavement: ½ inch maximum.
 - b. Other Paved Surfaces: ½ inch maximum.
 - c. Existing Underground Utilities: ½ inch maximum.
 - d. Railroad Tracks: ¼ inch maximum.

C. Settlement Control

1. Settlement monitoring shall comply with the Caltrans (completed) and BNSF permits (pending).
2. The Contractor shall establish, monitor, and maintain a system of permanent surface settlement points located along the pipe alignment. The points should be located along the pipeline alignment centerline and offset 10-feet north and south of the centerline, where permitted by Caltrans and the BNSF railroad within their right-of-ways. In addition, settlement points shall be installed at each major utility crossing, as directed by the Engineer. Settlement points shall be placed at a minimum on the shoulders and median of the freeway. For all non-freeway settlement points, 10-foot spacing shall be used.
3. The Contractor shall be responsible for repairing any damage resulting from tunneling or other construction operations. Pre-construction and post-construction inspection survey shall be completed along the pipeline alignment. The contractor shall perform a base line survey of all settlement monitoring points at least 7 days prior to commencement of jacking/receiving pit construction. Post-construction settlement monitoring shall be performed at 6 months and 12 months after construction is completed.

4. The Contractor shall also install a minimum of three Borros anchors, or similar approved devices, positioned on top of any existing underground utilities to measure vertical movements of these structures during pipe jacking or boring activities. The anchors should be positioned directly over each of the structures.
5. The settlement points and Borros anchors shall be surveyed once every 24-hour period, or more frequently if requested by the Engineer. Survey data from the previous work day shall be made available to the Resident Inspector at the start of the next day's work. Work will not begin until the Resident Inspector has reviewed the survey data and authorizes work to commence.
6. If survey data indicates any settlement of 0.02 feet or greater under freeway or roadways, or under the railroad right-of-way, Contractor shall immediately stop all work and implement remedial procedures as detailed in the Contractor's approved Settlement Control Plan. Jacking/boring operations shall resume only after all necessary precautions have been taken to prevent further movement, settlement or damage as reviewed by the Engineer.
7. Damage to the roadway, railway, or utilities resulting from jacking/boring operations shall be repaired by the contractor to the satisfaction of the owners of those entities at no cost to the Owner.
8. If required by the Engineer (on the basis of excessive surface settlement), the Contractor shall carry on work continuously without delay until completion, even if this requires working outside of normal working hours and/or working days. The Contractor shall have no claim for extra compensation as a result of such overtime work.

D. Qualifications of Jack-and Bore Contractor

1. The Jack-and-Bore Contractor shall have at least five years of experience in this type of work; shall have successfully completed at least three comparable projects greater than 400 feet in length and 36 inches in diameter with similar soil conditions, and using the proposed equipment; and shall be approved by the Engineer.
2. The Contractor's project superintendent managing the day-to-day operations shall have a minimum of five years of experience performing this type of work with at least 3 projects of similar size, ground conditions, and using the boring equipment proposed.

1.4 SUBMITTALS

- A. All submittals shall be in accordance with the requirements of Section 01300, Submittals, and the following additional requirements.
- B. At least three weeks before excavating shafts and beginning jack-and-bore operations, the Contractor shall prepare and submit a detailed written description of the following:
 1. Equipment and work methods proposed to be used.
 2. Personnel Qualifications.

3. Groundwater and surface water control methods, where applicable.
4. Acceptable sketches prepared and approved by a Professional Engineer registered in California showing the design and details of the jacking and receiving shafts, jacking and receiving shoring, head frame, shields, reaction blocks, arrangement of the jacks, and intended method to maintain proper grade and/or restrict movement of the carrier pipe within the casing.
5. Layout of work sites, including location of spoil storage areas.
6. Procedures and methods for the installation of the carrier pipe, including blocking details and location of blocking points.
7. The Contractor shall not proceed with this work until proposed equipment and methods have been reviewed by the Engineer.
8. Steel pipe supplier information and certification documents for steel casing to be supplied.
9. Welding procedures and welders' qualification records.
10. Alignment and level control system(s).
11. Type of grout mixing and pumping equipment, proposed grout mix design and proposed grouting procedures.
12. Settlement Control Plan to be implemented during construction indicating requirements, procedures, maximum limits of settlement, and required actions if limits are exceeded. Daily records of surveying reports shall be maintained. The plan shall be submitted not more than 30 days after award.
13. Calculations:
 1. Submit design calculations that demonstrate that the proposed casing pipe is capable of supporting the maximum stresses to be imposed during jacking. The calculation shall take into account ground and hydrostatic levels, jacking forces, external loads such as live loads due to traffic, and any other loads that may reasonably be anticipated during jacking. All loads shall be shown and described for the assumed maximum drive length.
 2. Submit calculation demonstrated that the soils behind the thrust block can transfer the maximum planned jacking forces exerted to the ground during pipe installation with an acceptable factor-of-safety of at least 1.5, without excessive deflection or displacement.

1.5 SITE CONDITIONS

- A. Observed groundwater levels taken in April and July 2001 indicate that groundwater table is below Elev. 1,072, or at least 36 feet below ground surface. Groundwater is not anticipated within the depth of the proposed pipeline alignment.

- B. It should be noted the proposed pipeline alignment is anticipated to be constructed through alluvial soils that are variable in gradation and density. The alluvial soils are overlain by the granular embankment fill materials. In addition, localized zones of granular and/or pervious materials are known to occur within the alluvial soil profile.

1.6 CUTTING, WELDING, BURNING, PIPE SWEATING

- A. Before any contractor and/or any subcontractor commences any cutting, welding, burning, or brazing (pipe sweating), the contractor shall obtain a HOT WORK PERMIT from Cal-OSHA, at (909) 383-4321 for an inspection of the area for a permit for such work.
- B. The HOT WORK PERMIT hard copy shall remain on the job site at the hot work location until such work is completed or the permit date and time has expired. The hard copy shall be returned to Occupational Safety and Health.

2.0 PRODUCTS

2.1 MATERIALS

A. Steel Casing Pipe

1. The steel casing pipe to be jacked shall be new 36-inch nominal diameter, with minimum wall thickness of 5/8-inch or as determined by the Contractor's Design Engineer based on jacking loads. The steel shall conform to ASTM A 283.

~~2. Steel casing shall be painted inside and out with two coats of bitumastic enamel coating — paint in accordance with AWWA C209.~~

JA
5/27/04
REQUIREMENT
DELETED

B. Ductile Iron Pipe

1. Ductile iron pipe materials (carrier pipe) shall be in accordance with Section 02610, Piping and Fittings.

C. Grout

1. Bentonite slurry mix, if used to fill voids, stabilize the borehole, or lubricate the steel casing during installation, shall be a fluid mixture of Wyoming bentonite and water.
2. The cement grout mix used to grout the annular space between the DIP and the casing pipe (i.e. backfill grout) shall be a fluid mixture of Type I or II Portland cement and water with a minimum 28-day compressive strength of 600 psi. The grout shall have properties such that it can be readily pumped into all annular spaces surrounding the DIP.

D. Surface Settlement Points:

1. Surface settlement points shall be established by an inscribed marking or approved surveyor's nail driven flush with the surface in asphalt or concrete paved areas. In landscaped areas, surface control points shall be established by driving a 2-inch by 2-inch by 18-inch long timer stake flush with the ground. Each control point shall have a tag or marking indicating the tunnel station and offset from centerline.

3.0 EXECUTION

3.1 GROUNDWATER AND SURFACE WATER CONTROL

- A. Perform all work in accordance with Section 02140, Dewatering.
- B. Jacking and receiving shaft excavations and pipe jacking/boring operations shall be conducted in the dry. The detailed design of any required dewatering system is the responsibility of the Contractor, subject to the Engineer's review.

3.2 JACKING AND RECEIVING SHAFTS

- A. The jacking and receiving shafts shall be braced with steel shoring or concrete of adequate strength to resist the jacking loads and serve the purpose intended.
- B. The Contractor shall install a 6" thick concrete working slab at the bottom of jacking and receiving shaft excavations to maintain pit subgrade during the work.
- C. The Contractor shall be required to furnish, install and remove to the extent required, thrust blocks or whatever provisions may be required in jacking/boring the casing pipe forward.
- D. Steel rails or beams, adequately supported on the bottom of the launch pit, shall be used for placement and alignment of each piece of casing pipe during installation operations.
- E. The Contractor shall be responsible for the removal of the excavation support elements for the jacking and receiving shafts, including:
 1. Breaking up, removing and disposing of concrete if so required by City of San Bernardino.
 2. Cutting off sheeting and furnishing and placing granular fill to the normal subgrade, as may be required following the installation operations.

3.3 JACK AND BORE OPERATIONS

- A. Casing pipe shall be installed by the jack-and-bore method, with the requirements as follows:
 1. The steel casing pipe shall be jacked forward into the soil while a boring auger rotates within the casing pipe to remove spoil.

2. The leading edge of the casing shall be provided with a mechanical means to prevent the auger and cutting head from leading casing so that there will be no unsupported excavation ahead of the casing.
 3. The auger and cutting head assembly shall be removable from within the casing in the event obstructions are encountered.
 4. The face of the cutting head shall be arranged to provide appropriate restriction to the free flow of soft or poor soil material. Any arrangement, which employs simultaneous boring and jacking, but does not have the above arrangement to prevent boring ahead of the leading edge of the casing pipe will not be permitted.
- B. The Contractor shall be responsible for establishing, measuring and maintaining the line and grade of the leading edge of the casing pipe. Any method that relies on estimating the position from slope of guide rails without direct sighting of the heading will not be acceptable. Casing invert elevation at the heading shall be determined with a water level or other suitable form of direct measure. Casing pipe joints shall be fully welded before being subjected to the jacking process.
- C. The use of water or other liquids inside or ahead of the casing (jetting) to facilitate casing emplacement and/or spoil removal is prohibited.
- D. Any voids created outside the casing during the advancement of the casing or due to the removal of material at the front of the casing shall be immediately filled with bentonite slurry or other suitable temporary stabilizing fluid. Such material shall maintain the borehole stability without loss of ground.
- E. The casing pipe joints shall be full penetration butt weld joints conforming to the AWWA recommendations for field welding of steel water pipe joints designated C-206-82 and with applicable portions of AWS D7.0.
- F. Edge preparation of joints to be butt-welded shall be beveled at a 30° angle, and fit-up with a 3/32 inch ($\pm 1/32$) root opening. Welders shall be qualified in accordance with the requirements of Section IX of the ASME Boiler and PV Code. Welding will not be permitted until the welder's qualification records have been received and reviewed by the Engineer.
- G. Completed butt weld joints shall be wire-brushed and re-coated with bitumastic enamel paint before continuing pipe jacking or boring.

3.4 INSTALLATION OF CARRIER PIPE

- A. Remove all loose soil and/or standing water from the casing pipe prior to installation of the carrier pipe.
- B. Install carrier pipe as shown on the Drawings in accordance with specified tolerances.

- C. Provide skids and blocking as required to prevent flotation, movement, or damage to the pipe during installation and backfill grout placement. Every individual pipe length or section shall be supported by at least two skids or blocking points that are at least 18 inches long.
- D. All DIP joints shall be completed in accordance with Section 02610, Pipe and Fittings.
- E. The DIP shall be tested in accordance with the requirements of Section 02610, Pipe and Fittings, prior to placement of the backfill grout around the DIP.
- F. Provide plugs or bulkheads at both ends of the casing to contain the backfill grout.
- G. Backfill grout shall be pumped through a pipe or a hose. The grout shall be proportioned to flow, and shall completely fill all voids between the carrier pipe and the casing.

3.5 SITE RESTORATION

- A. Remove all equipment and prepare the bottom of the shafts as a foundation for installation of pipes or manholes, which are to be constructed in open-cut.
- B. Restore the launch and receiving shafts in accordance with Section 02575, Pavement Repair and Resurfacing, and Section 02980, Landscape Restoration.

* * * END OF SECTION * * *

SECTION 02980

LANDSCAPE RESTORATION

1.0 GENERAL

- A. Landscape restoration shall be performed if required due to site work that damages adjacent property.

1.1 RELATED REQUIREMENTS SPECIFIED ELSEWHERE

- A. Protection and Maintenance of Work and Property: Section 01545
- B. Site Clearing: Section 02110
- C. Grading: Section 02210
- D. Trenching, Backfilling, and Compacting: Section 02221

1.2 SUBMITTALS

- A. Duplicate copies of a statement signed by the vendor certifying that each lot of seed has been tested by a recognized seed testing laboratory within 6 months before the date of delivery on the project.
- B. Duplicate copies of certification from grower certifying the grass species and locations of field from which sod was cut.

1.3 JOB CONDITIONS

- A. Areas landscaped and/or seeded prior to construction shall be restored to their original condition.
- B. Unless otherwise specified, the Contractor shall have the option of reseeding or resodding lawn areas that are disturbed during construction.
- C. A cover crop shall be sown in all areas other than landscaped areas that are excavated or disturbed during construction. Cover crop seeding shall follow backfilling operations by not more than three weeks.
- D. All plants or shrubs within landscaped areas that are damaged during construction shall be replaced with plants equal to that existing prior to construction. Any covenants or stipulations in easements shall be adhered to.
- E. All areas shown on the Plans to be planted, seeded or sodded shall be accomplished in accordance with this section.

2.0 PRODUCTS

2.1 TOPSOIL

- A. Topsoil that is required to be furnished by the Contractor from a source other than the area upon which it will be placed shall consist of fertile, friable soil, preferably of a loamy character, typical of the topsoil common to the locality, and it shall contain a normal amount of organic matter.
- B. It shall be obtained from arable land and shall be free from subsoil, refuse, and other deleterious substances. It shall be reasonably free from brush, roots, heavy clay, sticks and other litter and shall contain no stones or gravel larger than ½-inch in diameter.
- C. It shall be free of toxic amounts of either acid or alkaline elements and be capable of sustaining healthy plant life.
- D. It shall be approved by the Engineer before placement.

2.2 SEED

- A. Grasses and legumes for cover crop seed shall conform to the standards of State Department of Agriculture. Seed shall be furnished in standard containers on which shall be shown the following information:
 - 1. Common name of seed.
 - 2. Lot number.
 - 3. Net weight.
 - 4. Percentage of purity.
 - 5. Percentage of germination (in case of legumes percentage of germination to include hard seed).
 - 6. Percentage of weed seed content and inert material clearly marked for each kind of seed in accordance with applicable state and federal laws.

2.3 FERTILIZER

A. General:

- 1. Fertilizer shall be a standard commercial grade of organic or inorganic fertilizer of the kind and quality specified herein. It may be separate or in a mixture containing the percentage of total nitrogen, available phosphoric acid, and water soluble potash in the amounts specified.
- 2. All fertilizers shall be furnished in standard unopened containers with weight, name of plant nutrients, and manufacturer's guaranteed statement of analysis clearly marked, all in accordance with state and federal laws.

3. Fertilizer shall be ground to a fineness as required for the method of application.
- B. Lawn fertilizer:
- | | |
|---------------------------------|------|
| Total Nitrogen | 7 % |
| Available Phosphoric Acid | 16 % |
| Water Soluble Potash | 18 % |
- C. Cover Crop Fertilizer:
- | | |
|---------------------------------|------|
| Total Nitrogen | 7 % |
| Available Phosphoric Acid | 16 % |
| Water Soluble Potash | 18 % |

2.4 MULCH

A. Wood Cellulose Fiber:

1. Wood cellulose fiber mulch shall be specifically processed wood fiber containing no growth or germination inhibiting factors and shall be dyed a suitable color to facilitate inspection of the placement of the material.
2. It shall be manufactured in such a manner that after addition and agitation in slurry tanks with water, the fibers in the material will become uniformly suspended to form a homogenous slurry.
3. Each package shall be marked by the manufacturer to show the air dry weight content.

B. Peat:

1. Peat shall be a natural domestic product of either sphagnum moss, reed or sedge peat, taken from a freshwater site, free from lumps, roots and stones.

C. Straw:

1. All straw mulch material shall be in an air dried condition free of noxious weeds, weed seeds, and other materials detrimental to plant life.
2. Straw shall be seasoned before bailing or loading.
3. Straw mulch shall be suitable for spreading with mulch blower equipment.

2.5 SOD

A. Imported Sod:

1. Sod shall be of first quality turf grass sod compressed of acceptable grass mixtures, relatively weed free.
2. Sod shall be machine cut to a uniform soil thickness not less than 3/4 of an inch or more than one inch (1"). Individual sod pieces shall be cut to a standard width and to an acceptable length that provides for efficient and proper installation.
3. Sod shall be harvested, delivered, and installed within a 48-hour period.
4. The Contractor upon request, shall submit one standard piece of sod for the Engineer's approval.

B. Native Sod:

1. Native sod shall be replaced in the lawn of original removal.
2. The area of sod to be removed shall be laid out in squares or strips of such size as to provide easy handling and matching. The sod shall then be carefully cut along these lines taking care to keep all cuts straight and strips of the same width. After the sod has been cut vertically, it shall be removed to a uniform depth with an approved type of sod cutter. This operation shall be performed in such a manner as to ensure uniform thickness of sod throughout the operation.
3. As the sod scalping proceeds, the sod strips shall be placed in neat piles at convenient locations and from then on they shall be maintained in a damp condition continuously until the sod strips are ten (10) days before replacement of the lawn.

2.6 PLANT MATERIALS

- A. Plants shall be healthy, in vigorous growing condition, and be guaranteed true to size, name and variety. Nomenclature shall be listed in Standardized Plant Names, Second Edition, 1942.
- C. Size and quality shall be equal to existing plants or as shown on the Plans. Plants shall be No. 1, nursery grown, freshly dug, of normal growth and habit, free from disease and insects.

3.0 EXECUTION

3.1 LAWN SEEDING

- A. All areas to be put into lawn shall have a minimum depth of 6 inches of topsoil.
- B. Immediately prior to placing topsoil, the surface area upon which it is to be placed shall be cleaned of objectionable matter and the area be smoothed and compacted.
- C. The finish grade of all the areas to be put into lawn shall be smooth, without visible depressions or mounds and shall be flush with the top of adjoining curbs, walks and drives.

- D. After establishing the finish grade, all areas shall be raked, rolled and again hand raked, removing all rocks, weeds and debris.
- E. Commercial fertilizer shall be applied at the rate of eight (8) pounds per thousand (1,000) square feet.
- F. Lawn seed shall be seeded over all areas to be put into lawn at the rate of three (3) pounds per thousand (1,000) square feet.
- G. After seeding, ground horticultural peat moss shall be spread 1/4-inch deep with an approved spreader over all seeded areas.
- H. The exact time for seeding will be determined by actual weather conditions. The normal satisfactory periods for seeding shall be considered as being March 1 and May 1 and between September 15 and October 20.
- I. When delays in operation carry the work beyond the most favorable planting season or when weather conditions are such that satisfactory results are not likely to be obtained for any stage of the seeding operations, the Contractor will stop the work and it shall be resumed when the desired are likely to be obtained or when approved alternates or corrective measures and procedures are adopted.
- J. Maintenance shall commence immediately on planting and the lawn area shall be kept damp for 10 days to 2 weeks. Protect all seeded areas by watering, mowing, and replanting as necessary for at least thirty (30) days and as long as necessary to establish a uniform stand of grass, and a minimum of two (2) cuttings.

3.2 SOD

- A. Prior to placing the strips of sod, the scalped area shall be carefully shaped to proper grade and be thoroughly compacted. Wherever the construction operations have resulted in the placement of unsuitable or poorer soils in the area to be resodded, the surface shall be left low and covered with topsoil.
- B. The finished grade, after shaping and compacting the topsoil, shall be thoroughly dampened prior to and immediately before replacing the sod.
- C. The sod shall be replaced to the required grade, taking care to butt each piece tightly against the adjacent one.
- D. Upon completion, the sod shall be dampened and rolled with a lawn roller.
- E. All sod shall be kept moist during the first week of sodding. Water shall be provided for each of the next three weeks to provide a minimum of two inches of moisture per week

3.3 COVER CROP SEEDING

- A. Seeding shall not be done during windy weather or when the ground is frozen, excessively wet or otherwise untillable.
- B. Seed may be sown by one of the following methods:
 - 1. Hydro-seeded which utilizes water as the carrying agent, and maintaining continuous agitation through paddle blades. It shall have an operating capacity sufficient to agitate, suspend and mix into a homogenous slurry of the specified amount of seed and water or other material. Distribution and discharge lines shall be large enough to prevent stoppage and shall be equipped with a set of hydraulic discharge spray nozzles which will provide a uniform distribution of the slurry.
 - 2. Blower equipment with an adjustable disseminating device capable of maintaining a constant, measured rate of material discharge that will ensure an even distribution of seed at the rates specified.
- C. Grass seed shall be seeded at the rate of 130 pounds per acre.
- D. Fertilizer shall be applied at the rate of 300 pounds per acre.
- E. Wood cellulose fiber shall be applied at the rate of 3 tons per acre.
- F. The exact time for seeding will be determined by actual weather conditions. The normal satisfactory period for seeding shall be considered between March 1 to June 1 and September 1 to November 1 unless otherwise authorized by the Owner, except that the Contractor may perform seeding operations from June 1 to September 1, provided that he waters the new grass to the satisfaction of the Owner.
- G. When delays in operations carry the work beyond the most favorable planting season, or when weather conditions are such that satisfactory results are not likely to be obtained for any stage of the seeding operations, the Contractor will stop the work and it shall be resumed only when the desired results are likely to be obtained or when approved alternates or corrective measures and procedures are adopted.
- H. The Contractor shall protect all seeded areas from erosion until final inspection and acceptance has been made. Areas damaged by erosion shall be repaired by the Contractor at his own expense.

3.4 PLANTING PITS

- A. Trees: Vertical sides, flat bottom, circular or square 6-inch minimum planting soil below ball and/or roots, diameter, or side dimension 2 feet greater than root system or ball diameter.

B. Shrubs conform to A above, except diameter or side dimension 1 foot greater than ball diameter or root.

C. Bulbs, bedding plants and ground cover 12 inches below finish grade.

3.5 PLANTING TREES, SHRUBS, GROUND COVER, BULBS AND BEDDING PLANTS

A. Use planting soil beneath and around cavity between plant ball or roots and pit sides. Tamp base firmly, place plant or tree, tamp soil in layers, thoroughly water each layer, loosen and fold burlap away from top of ball into pit. Fill balance of cavity with planting soil. Soak and continuously maintain adequate moisture.

B. Use approved root transplanting compounds and herbicides for bulbs and plants to prevent disease and assure best plant growth.

C. Leave watering "saucers" around each plant.

D. Support trees immediately after planting by staking and/or guying to maintain trees in plumb position.

E. Apply mulch where shown or noted on the Drawings. Mulch depth 3 inches unless otherwise noted.

F. Fertilize all trees, shrubs, and ground covers at time of planting.

3.6 FINAL INSPECTION

A. Final inspection for seeded areas will not be made until 30 days following completion of all seeding, fertilizing, and mulching as specified. Damage caused by the Contractor to areas which have been seeded or sodded shall be repaired and/or replaced by the Contractor at his own expense.

3.7 GUARANTEE

A. Guarantee of planting and seeding shall continue for one year from date of final project acceptance. Contractor shall replace all plants or sod dead or dying within the guarantee period, or reseed lawns and cover crop where required. Guarantee shall include both materials and labor. Replacements shall be the same as originally planted.

END OF SECTION

SECTION 03300

CAST IN PLACE CONCRETE

1.0 GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

- A. Testing Laboratory Services: Section 01410
- B. Concrete Formwork: Section 03100
- C. Concrete Reinforcement: Section 03200

1.2 QUALITY ASSURANCE

- A. Delivery: Furnish a certificate with each truckload of concrete product delivered to the site, indicating the composition and quality of the mix. Include size and weight of each aggregate, amount of cement, amount of water and amount and kind of any additives included in the concrete, grout fill, or mortar.
- B. Standards: All applicable standards of the following:
 - 1. American Concrete Institute - ACI
 - 2. Concrete Reinforcing Steel Institute - CRSI
 - 3. Uniform Building Code - UBC
 - 4. Other local codes or criteria noted on drawings.
- C. Concrete Consistency:
 - 1. Test each truckload of concrete for slump. Calibrate each mixer or haul unit to be used by measuring slump near the beginning and near the end of the discharge cycle. Mix units determined by the Engineer to be deficient in mixing capability shall not be used in subsequent deliveries. Slump testing procedures per ASTM C143.
 - 2. Consistency per values below with tolerance of ± 1 inch.
 - a. 2-3 inches slump for structural elements 12 inches and greater in thickness.
 - b. 2-4 inches slump for structural elements less than 12 inches in thickness and columns.
- D. Concrete Test Cylinders:
 - 1. Prepare a minimum of three test cylinders for each location (slab, wall, column, beam, etc.) for each days placement or each 50 cu. yd. whichever is greater.
 - 2. Test set of 3 cylinders as follows:
 - a. One at 7 days.
 - b. Two at 28 days.

- 3. Prepare and test cylinders per ASTM C31 and C39.
- E. Prior to placement have available at placement location all tools, cylinder molds, slump cone, rod, curing containers and all other apparatus required for sampling and testing.
- F. Air Entrained: One test for each mix design.

1.3 SUBMITTALS

- A. Concrete mix design (for each concrete type used) by independent laboratory, including strength tests of 3 cylinders proportioned to mix design formula.
- B. Certification of quality of all concrete, mortar, and grout mix design ingredients including admixtures with supporting test data, mill quality control results and all information specified and requested by the Engineer.
- C. Qualifications of Quality Assurance Control personnel responsible for concrete consistency, strength, air content and all testing.
- D. Curing materials and methods proposed with certification statements of materials quality.
- E. Test results, in approved format, at specified intervals for all field sampling and specimens.
- F. Certification of quality and type of epoxy bonding materials.
- G. Trip tickets for each load of concrete, grout or mortar indicating weights of all materials and additives used in the batch.
- H. Location of construction joints not shown on the plans.

1.4 STORAGE OF MATERIALS

- A. Maintain in continuously clean environment and in manner required to maintain homogeneity.
- B. Cements, grouts, and mortar containerized and kept in dry humidity environment. Engineer shall reject materials which have hardened or show any evidence of initial hydration.

2.0 PRODUCTS

2.1 CONCRETE

- A. ASTM C94 and mix design approved by Engineer.
- B. Compression strength and water cement ratio: The minimum compressive strength and cement content of concrete shall be not less than that shown in the tabulation that follows. The Engineer may order the cement content for any class of concrete to be increased over the quantity specified in the tabulation if it is determined that such increase is necessary to attain the required strength. Such increased quantities of cement, if so ordered, shall be furnished by the Contractor at no additional cost to the Owner.

Class of Concrete Min.				
28-Day		Max. Size	Min.	
Compr. Strength		Aggregate	Cement	Max. W/C
(psi)	Type of Work	(in.)	pounds	Ratio
			per cu yd	
4,000	Walls and slabs on grade	1½	564	0.45
4,000	Roof and floor slabs	1	564	0.45
3,000	Cradles, thrust blocks, encasements and all other uses	1½	517	0.50
Lean	Encasement of dowels for future expansion	--	188	--
			(235 max.)	

C. Cement ASTM C150:

1. Type II for all wastewater holding or process structures.
2. Type I or II for all other structures.

D. Aggregates:

1. Conform to ASTM C33.
2. Maximum wear 50% at 500 revolutions, AASHTO T96.

E. Water:

1. Clear free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances.

F. Admixtures:

1. Use only those specified in approved mix design.
2. Air entrain all concrete unless elsewhere excepted, with agent conforming to ASTM C260. Freshwater concrete air content between 4% and 6% by volume.
3. Apply in strict accordance with manufacturer's printed instructions.
4. No chloride contents permitted.
5. Compatible with coatings specified elsewhere.

2.2 AGGREGATE FOR MORTAR

A. Conform to 2.1 except gradation as follows:

Sieve Size	Percent Passing
<u>Square Opening</u>	<u>By Weight</u>
No. 4	95 - 100
No. 8	80 - 90
No. 16	55 - 97
No. 30	30 - 60
No. 50	12 - 30
No. 100	0 - 10

2.3 GROUT

- A. For equipment and column bases and drilled in anchors use nonshrink, nonstaining, premixed grout, Masterflow 713 by Master Builders; or equivalent. Mix in accordance with the manufacturer's directions.
- B. For Fill: Driest consistency practical composed of 1 part Portland Cement 3 parts sand (by volume). Aggregate proportions may be varied slightly to give the most workable mix.
- C. For placement at base of walls, one part fine aggregate, one part cement. In a thick cream consistency.
- D. Cure in accordance with manufacturer's recommendations.

2.4 CURING MATERIALS

- A. Polyethylene Sheeting 0.004 inch thick.
- B. Waterproof Paper: Polyethylene-coated, Fed. Spec. UU-B-790 Type I, Grades A, B, C, Style 4. Define lap control lines clearly by printed markings.
- C. Masonry Sand: ASTM C144 (Maintained continually moist).

3.0 EXECUTION

3.1 MIXING AND TRANSPORTATION

- A. Ready-Mixed Concrete: Conform to ASTM C94 Alternate No. 3.

3.2 PLACING

- A. Deliver only in sufficient quantities required for specified time interval use and placement. Discard concrete having initial set before placement. No remixing with water or supplementing with other materials will be permitted once initial set has occurred. Initial set as evidenced by typical hydration characteristics to be determined by Engineer and Contractor quality assurance representative.
- B. Place as nearly as possible to final position to avoid segregation of the materials and displacement of reinforcement. Placement shall be completed within 30 minutes after water is first added to the mix. However, at the Engineer's discretion if climatic and temperature conditions are suitable and when the concrete is continually agitated, the time may be extended to 1-1/2 hours.
- C. Place no concrete in the absence of the Engineer.
- D. Do not change consistency (slump) for a given placement without the Engineer's written permission.
- E. Keep open trough and chutes of steel or steel lined, clean and free from coatings of hardened concrete.
- F. Do not drop concrete a distance of more than 5 feet unless approved in writing by the Engineer.
- G. Do not place concrete in horizontal members or sections until the concrete in the supporting vertical members or sections has been consolidated and a 2-hour period has elapsed since placement in the vertical member to permit shrinkage to occur.
- H. In walls containing door and window openings, hold up placements at the top and bottom of the openings. Stop other placements at levels to conform to drawing details.
- I. Layout and sequence of placing of concrete in monolithic structures as shown on the drawings or approved by the Engineer.
- J. Within a placement, deposit concrete in horizontal layers not to exceed 18 inches in depth. Place at rate such that: (1) no concrete surface shall obtain initial set before additional concrete is placed on it and (2) yielding of forms is not so great as to cause the concrete surfaces to exceed the tolerances specified.
- K. Unless specified otherwise, place all slabs and finished floors to finish elevation in one continuous operation, except that the Contractor may place a separate finish topping if prior approval is received from the Engineer. Floor and roof slab sectional thicknesses shown are minimum thicknesses. Slopes on floors or roofs increase, rather than decrease, slab thicknesses.
- L. Where a separate finish topping is placed, increase structural slab thickness by the maximum thickness of the finish topping and maintain finished floor elevation as noted on the drawings.
- M. Construction Joints:
 - 1. Locate construction joints as shown on the drawings or as approved by the Engineer.

2. Locate construction joints so as not to impair the strength of the structure, and only at locations shown on the drawings or approved by the Engineer.
 3. Construct bulkheads to neatly fit reinforcement and waterstops and prevent concrete leakage.
 4. Provide waterstops or sealants in construction joints where required.
 5. Unless shown otherwise, key all construction joints.
 6. Continue reinforcement through construction joint unless otherwise shown or noted.
 7. Before placing concrete against previously placed concrete, thoroughly roughen and clean by wet sandblasting or green cutting with an air-water jet.
 - a. Use air-water cutting at the proper time after the initial set. Use a high pressure air-water jet to expose clean, sound aggregate without undercutting the edges of the larger aggregate. Protect adjacent subgrade when cutting is used on slab edges.
 - b. After cutting or sandblasting, rinse the surface until wash water contains no cloudiness. Dispose of wastes from cutting, washing and rinsing so they do not stain or abrade exposed surfaces.
 8. Place concrete continuously to a predetermined construction joint.
- N. Care shall be taken in placing concrete through reinforcement so that no segregation of the coarse aggregate occurs. On the bottom of beams and slabs where the congestion of steel near the forms makes placing difficult, a layer of mortar, of the same strength as used in concrete, shall first be deposited in the forms, followed immediately by the concrete. The thickness and use of this mortar layer shall be as approved by the Engineer.
- O. Special care shall be taken to prevent splashing forms or reinforcement with concrete. Any hardened concrete or partially hardened concrete on the forms or reinforcements above the level of the concrete already in place shall be removed before proceeding with the work.
- P. Cold Weather Placement:
1. Concrete shall be placed only when the temperature is at least 40°F., and rising, unless permission to pour is obtained from the Engineer.
 2. Material shall be heated and otherwise prepared so that batching and mixing can proceed in full accord with the provisions of this Specification.
 3. Suitable means shall be provided for maintaining the concrete at a temperature of at least 50°F for a period of at least the first five (5) days and at a temperature above freezing for the remainder of the specified curing period, except that where high-early-strength cement is used, this period may be reduced to 72 hours. The methods proposed for heating the materials and protecting the concrete shall be approved by the Engineer.
 4. Salt, chemicals, or other materials shall not be mixed with the concrete for the purpose of preventing freezing. Accelerating agents shall not be used.

Q. Hot Weather Placement:

1. The temperature of fresh concrete at the time of placement during hot weather shall be a maximum of 90°F to prevent an accelerated setting of the concrete.
2. A retarding densifier admixture shall be used when the high expected atmospheric temperature for the day is 85°F or above. Admixture shall be used in accordance with the manufacturer's recommendations.

R. Placing Concrete Against Earth:

1. Unless otherwise called for on the drawings, earth cuts shall not be used as forms for vertical surfaces without the prior approval of the Engineer.
2. Concrete placed on or against earth shall be placed only upon or against firm, damp surfaces free from frost, ice and standing or running water. Concrete shall not be placed upon mud, or upon fills until the required compaction has been obtained.

S. Placing Concrete Slabs:

1. Smooth subgrade surface irregularity with thin film of masonry sand prior to placing vapor barrier.
2. Place vapor barrier on subgrade in maximum widths commercially available. Longitudinal laps 6 inch minimum. End laps 2 feet minimum.
3. Edge and side laps to be in continuous contact. Place materials to maintain tight lap contact.
4. Repair any tears in the material.
5. Place concrete without displacing vapor barrier.

T. Depositing Concrete in Water:

1. Concrete may be deposited in water only when specifically authorized.
2. Methods and equipment used shall be acceptable to the Engineer.
3. When deposited by the tremie method, the tremie shall be watertight and sufficiently large to permit a free flow of concrete. The discharge end shall be kept submerged continuously in the concrete and the shaft kept full of concrete to a point well above the water surface. Placing shall proceed without interruption until the top of the concrete has been brought to the required height.

3.3 COMPACTING

- A. Compact all concrete with high frequency internal vibrators immediately after placing.
- B. Use external vibrators for compacting concrete where the concrete is inaccessible for adequate compaction by internal vibrators; construct forms sufficiently rigid to resist displacement or damage from external vibration.

- C. Penetrate concrete with a sufficient number of vibrations immediately after it is deposited. Move vibrator throughout the mass so as to thoroughly work the concrete around reinforcement and embedded fixtures and into corners and form recesses. Vibrate the minimum time required to compact the concrete in place and not cause separation of the materials. Concrete shall be compacted to maximum density as determined by tests for yield. Select vibrator size to efficiently accommodate reinforcement clearances.

3.4 CURING AND PROTECTION

A. General:

1. Maintain at site ready to install, before actual concrete placing begins, all equipment and materials needed for optimum concrete curing and protection; maintain extra vibrators on standby in case of malfunction of any unit.
2. Protect finished surfaces or edges from stains, abrasions and breakage during the entire construction period.
3. Protect all concrete from accelerated drying and excessive heat at all times. Close all galleries, conduits and other formed openings through the concrete during the entire curing period and as long thereafter as practicable to prevent drying of concrete by air circulation.
4. Install slab curing covers immediately after initial set or as soon as free water has disappeared from the surface of the concrete after finishing or surfacing.

B. Water Curing:

1. Use water curing specified herein for all walls and slabs where watertight construction is required.
2. Keep concrete continuously wet by covering with an approved material or by a system of perforated pipes or mechanical sprinklers or other approved methods. (Periodic wetting acceptable.)
3. Keep forms wet at all times to prevent opening of joints and the drying out of the concrete.
4. Water for curing shall be clean and free from any elements which might cause objectionable staining or discoloration of the concrete.
5. Cover surfaces completely with sheeting. Where a single sheet does not cover the entire surface, lap ends and edges at least 4 inches and continuously seal with tape or other suitable means recommended by the manufacturer.
6. Continue waterproof sheet curing for 7 days. Maintain sheeting and edge and end seals intact for entire period. Repair immediately any breaks in the sheeting envelope.

C. Curing Compounds (Use only when specifically approved and for optimum climatic conditions):

1. Do not use curing compounds unless their use is authorized in writing by the Engineer. Curing compounds unacceptable where concrete is exposed to the direct rays of the sun or accelerated drying conditions.
2. Curing compounds shall not be used unless their use is face membrane type and shall be applied in accordance with the manufacturer's recommendations. They shall be of such composition and characteristics as will spread readily on moist concrete and deposit a hard, tenacious film without permanently coloring the concrete surfaces that will be exposed. The

resultant film shall adhere to the concrete surface without chemical reaction therewith, and shall not peel. Maintain coverage for 28 days to prevent detrimental loss of water from the concrete.

3. Prior to applying curing compounds to formed surfaces, the surfaces shall be moistened with a spray of water immediately after forms are removed. Moistening shall be continued until the surfaces will not readily absorb more water. The compound shall be applied as soon as the moisture film has disappeared and while the surface is still damp.
4. On unformed surfaces, the compounds shall be applied immediately after finishing and after bleeding water and "shine" has disappeared.
5. Curing compounds shall not be used on surfaces where future bonding, painting or protective coating is required. In cold weather, curing compounds shall not be used on concrete surfaces that are kept at curing temperature by the use of steam.

D. Saturated Sand Curing:

1. Horizontal construction joints and finished surfaces, cured with sand, shall be kept covered with a minimum thickness of one inch of sand. It shall be kept uniformly distributed and continuously wetted with clean water for a period of 7 days.

3.5 REPAIRING CONCRETE

- A. Immediately after removal of forms, break back all form ties and inspect concrete surfaces for defects. Complete repair of defects within 48 hours after removal of forms. No repairs shall be made until the defects have been reviewed and method of repair approved by the Engineer.
- B. Remove all defective or damaged concrete, including honeycombed, sand streaked, or fractured material from the area to be repaired. Chip out areas to one inch minimum depth. Edge shall be squared with the surface to eliminate feather edges.
- C. Before placing the repair material obtain Engineer inspection. Clean area free of chipping dust, dried mortar, and all other foreign materials.
- D. Keep surfaces to be repaired continuously wet for at least three hours prior to placing new concrete or mortar. No free water on the surface when the repair material is placed.
- E. Apply a bonding agent to the area to be repaired before placing repair material. Apply the bonding agent per manufacturer's published instructions attached to container.
- F. For all repair surfaces permanently exposed to atmosphere use white cement in proportions found by trial to be effective in producing a color that, in the hardened patch, will match the surrounding concrete surface.
- G. Make repairs or patch form tie holes by (1) dry-packing, (2) filling with concrete, or (3) plastering with mortar or a combination of all 3 in conformance with the following:
 1. Use the dry-pack method for holes at least one inch deep where the depth is equal to, or greater than the smallest surface dimension of the defect, such as cone-bolt or form tie holes, and for narrow slots cut for the repair of cracks. Do not use the dry-pack method where lateral restraint cannot be obtained. Place and pack dry-pack mortar in layers having a compacted thickness of approximately 3/8 inch. Solidly compact each layer over its entire

surface by use of a hardwood stick and hammer. Do not use metal tools for compacting. Compact surface just flush with adjacent area. Do not use steel finishing tools or water to facilitate finishing.

2. Use concrete replacement for (1) holes extending entirely through concrete sections; (2) for holes larger than one square foot and deeper than four inches in which no reinforcement is encountered; (3) for holes larger than 1/2 of one square foot where reinforcement is exposed. Concrete used for replacement shall be of the same strength and mixture as used in the structure except for color matching as specified above.
3. Use mortar replacement for holes too wide to dry-pack and too shallow for concrete replacement and when approved by the Engineer for other conditions not covered above.

H. Cure all repairs with the same methods as new concrete.

3.6 CONCRETE FINISHES AND TOLERANCE

A. General Finish:

1. Finish concrete surfaces to conform with the following table unless otherwise noted on the drawings.

<u>Formed Surfaces</u>	<u>System</u>
Exterior - Exposed and One Foot Below	F4
Exterior - Below Grade	F2
Interior	F4
<u>Slabs</u>	
Tops of exterior footings in contact with soil or backfill	U2
Exterior - Except as Otherwise Noted	U5
Interior - Walking Surface Except as Otherwise Noted (with hardener)	U4
Interior - Tank and Channels	U4
Exterior and Interior Walks on or over structures including interior clarifier slab to receive swept in grout fill	U1

B. Formed Surfaces: Finishes for formed surfaces shall be as designated below:

1. Finishing for F1 and F2 finishes consists of concrete repairing only, which is to be completed within 48 hours after forms are removed.
2. Finishing for F3 and F4 finishes shall immediately follow concrete repairing and be completed within 96 hours after the forms are removed. Except where forms are left in place for the duration of the curing period, finishing shall be done during the curing period, keeping the interruptions to the curing process as short as possible. Where forms left on prevent finishing during the curing period, finishing shall be completed within 48 hours after forms are removed. All finishes shall receive a minimum of 24 hours of curing after completion of the finish. Curing shall be carefully done so as not to disturb or remove any of the mortar.

3. Finish F1: Rough formed surface with defective concrete repaired and form tie holes and other holes over 1/2 inch deep filled. Forms may be built with a minimum of refinement and form sheathing may be any material that will not leak mortar or yield beyond specified tolerances when the concrete is vibrated.
4. Finish F2: Smooth, formed concrete surface with all fins, projections and loose material removed and defective concrete and form tie holes and other holes over 1/2 inch deep, repaired and filled. Forms in contact with concrete shall be plywood or steel.
5. Finish F3: Smooth, formed concrete surface with all fins, projections and loose material removed, and defective concrete, form tie holes, air bubble holes, surface pits, holes from defective forms, nailhead holes and similar surface defects, repaired and filled. Forms in contact with concrete shall be plywood or steel. Form construction shall be planned so that if any pattern from the forms is left in the concrete surface it will harmonize with the structure or building. All joints shall be horizontal or vertical.
6. Finish F4: Exceptionally smooth, formed concrete surface with all fins, joint marks, bulges, projections and loose material removed. Sandblast to expose air bubble holes, surface pits and similar minor surface defects. Defective concrete, form tie holes, holes from defective forms, and other holes too large to fill by "sack rubbing" shall be repaired and filled. Finish with sack rubbing as follows.
 - a. Thoroughly wet the surface and begin treatment while the concrete is still damp. Use 1 part cement, 2 parts (by volume) of sand which will pass a No. 16 screen, and enough water so that mortar consistency will be that of thick cream. Rub mortar thoroughly over the area with clean burlap or a cork or sponge rubber float to fill all pits, surface holes and air bubble holes. While the mortar in the pits is still plastic, rub the surface with a dry mix of mortar. This dry rub shall remove all excess mortar and place enough dry material in the pits to stiffen and solidify the mortar flush with the surface. No material shall remain on the surface except that within the pits. When the ambient temperature is 85°F or higher, keep the mortar continuously damp by means of a fog spray for 24 hours during the setting period. Take care that the fog spray does not remove any of the mortar. Break finish for any area only at natural breaks in the finished surface.
 - b. Rub all surfaces that are to be finish painted with a carborundum stone to provide a smooth texture and to remove any latent material on the surface. Pre-blast walls to remove any residual form oils prior to finishing when walls are to be finish painted.
 - c. Form requirements shall be the same as Finish F-3.

C. Unformed Surfaces:

1. Working on unformed surfaces in various finishing operations shall be held to the minimum required to produce the desired finish. Use of any finishing tool in areas where water has accumulated will not be allowed. Work in these areas shall be delayed until the water has been absorbed, has evaporated, or has been removed by draining, mopping, dragging off with a loop of hose, or by other means. In no case, shall cement or mixture of cement and sand be spread on the surface to absorb excess moisture nor shall such materials or water be added to facilitate troweling. Joints and edges, unless specified otherwise, shall be carefully finished with edging tools.
2. Finishes for unformed surfaces shall be as designated below:

- a. Finish U1: Even, uniform finish. Consolidate level and screed concrete to obtain an even, uniform surface. Surplus concrete shall be removed immediately after consolidation by striking it off with a sawing motion of the straight edge or template across wood or metal strips, that have been set as guides. When the surface is curbed use screed strips at approved intervals. For long, narrow stretches of curved surfaces such as on invert paving, a heavy slip form may be used. In the case of extensive flat paving, a paving and finishing machine is preferred.
- b. Finish U2: A wood float finish. Follow treatment specified for finish U1 by floating either by hand, or by power driven equipment. Floating to be started after some stiffening has taken place in the surface concrete and the moisture or "shine" has disappeared. Work the concrete no more than necessary to produce a surface known as "wood float finish" which is uniform in texture and free of screed marks. Do any necessary cutting and filling during the floating operations.
- c. Finish U3: A steel troweled finish. Follow the treatment specified for the finish U2, except leave a small amount of mortar without excess water at the surface to permit effective troweling. Start steel troweling after the moisture film or "shine" has disappeared from the float surface and after the concrete has hardened enough to prevent an excess of fine material and water from being worked to the surface. Trowel with firm pressure that will flatten the sand surface left by the floating and produce a dense, uniform surface free of blemishes, ripples and trowel marks.
- d. Finish U4: A hard, steel troweled finish burnished. Follow the treatment specified for finish U3 with additional steel troweling after the surface has nearly hardened, using firm pressure and troweling until the surface has a burnished appearance.
- e. Finish U5: Broom finish. Follow the treatment specified for finish U3 by roughening the surface immediately after troweling with a fiber bristle broom in a direction perpendicular to the direction of traffic. Broom grooves not more than 1/16 inch deep. After brooming, neatly tool all joints and edges to configuration.
- f. Finish U6: Anti-slip finish. Follow the treatment specified for finish U3 and immediately after troweling, dust 30 to 40 lbs. of regular non-slip aluminum oxide 14/36 grit abrasive grain uniformly over each 100 sq. ft. of area. Trowel the grit into the surface and after troweling, brush with a fiber bristle broom in a direction perpendicular to the direction of traffic. Broom grooves not more than 1/16" deep. After brooming neatly tool all joints and edges to configuration.

D. Tolerances:

1. Unless otherwise required, allowable tolerances for concrete surfaces shall be in accordance with those shown in the table below. Surface irregularities are classified as either "abrupt" or "gradual". Offsets caused by displaced or misplaced form sheathing, lining, or form section or by defective form lumber shall be considered as abrupt irregularities. All others are classed as gradual irregularities. Gradual irregularities shall be measured with a template consisting of a straight edge for plane surfaces and its equivalent for curved surfaces.
2. The length of the template for testing formed surfaces shall be 5 feet. The length of the template for unformed surfaces shall be 10 feet. Maintain a 5 foot length and 10 foot length steel template on the job site.
3. Maximum allowable irregularities in concrete:

Finish <u>Designation</u>	Irregularity in Inches	
	<u>Gradual</u>	<u>Abrupt</u>
F1	1	1/2
F2	1/2	1/4
F3	1/4	3/16
F4	3/16	3/16
U1 thru U6	1/8	1/8

3.7 TESTING AND REPAIRING CONCRETE STRUCTURES

A. Testing:

1. Separately test each individual chamber that will contain liquid by filling to the overflow with water after the 28-day design strength of the concrete has been obtained. Repair any visible leakage. Damp spots that do not run may be acceptable if below ground or not on walls common with pump rooms or passageways.
2. Allowable leakage not to exceed 0.1% of the volume contained in the chamber in a 24 hour period. Leakage in excess of the allowable amount requires repair to reduce leakage and will be considered to lack watertightness.

B. Repairs:

1. In the event that the structure is not watertight, outline a procedure for repair prior to proceeding with the repair work. Complete any repairs to new work as per specifications at Contractor expense.
2. Approved repairs can include, but not necessarily be limited to one or a combination of the repairs listed below. Use of these techniques is not to be construed as a warranty by the Engineer that the methods outlined will satisfy leakage repair requirements:
 - a. Replace defective concrete.
 - b. Grouting of the joint by drilling grout holes to the center of the structural unit and forcing grout into the joint under pressure.
 - c. Cutting of a bevel groove on the pressure side of the joint. Groove 1/2 to 3/4 inch in width and depth caulked with epoxy joint sealer in accordance with the manufacturer's instructions.

3.8 UNSATISFACTORY CONCRETE

- A. Any concrete placed which fails to meet or exceed the specified strength requirements as determined from molded cylinders or cores, or to meet the density or surface requirements, or which has been frozen during placing or curing, shall be removed and replaced with satisfactory materials at the Contractor's expense.

B. Method of determining unsatisfactory concrete: Visual appearance characteristic of rain or freeze damage to concrete which is apparent to the Engineer.

* * * END OF SECTION * * *